# How can we More Accurately Measure Emission Fluxes of Precursor Gases Emitted from Area Sources that Form Secondary PM?

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research and development

## Science Questions

What are spatial and temporal emissions of $NH_3$ and other PM precursor gases from unconfined area sources and how can advanced measurement techniques address the spatial extent and inhomogeneous nature of these sources?

How much $NH_3$ deposits near a source and is therefore unavailable for secondary aerosol formation?

Important Example: Large-scale Animal Feeding Operations (AFOs) dominate the national $NH_3$ emission inventory but source profiles, transport, and fate data are not well developed. Measurement techniques that provide spatially and temporally resolved PM precursor gas emission and fate information are needed for source monitoring, regional modeling and emission abatement strategy assessment.

## Research Goals

Develop and verify a measurement method to quantify PM precursor gas emissions from unconfined area sources.

Utilize this method to quantify $NH_3$ emissions from representative AFOs.

Develop, characterize, and deploy a low-cost measurement method to determine the local fate of $NH_3$ emitted from AFOs.

Combine source and fate data to quantify the net emission of $NH_3$ from AFO sources.

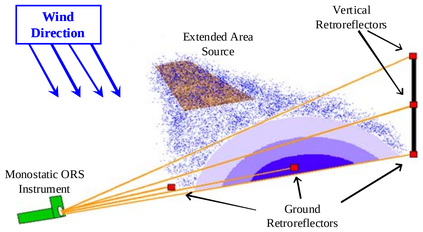
## Government, University & Industry Partners

- USDA
- DHS
- DOD
- EPA OWSER
- EPA R1
- EPA R8
- Univ. of KY
- NCSU
- GA Tech
- Purdue Univ.
- Boreal
- Unisearch
- Industrial Monitoring and Control Corp.
- Three Rivers Solid Waste Authority
- Waste Management Inc.

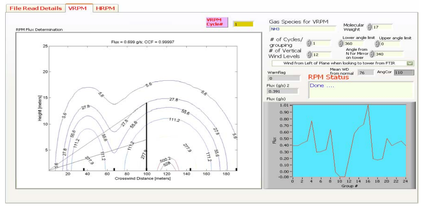
## Methods/Approach

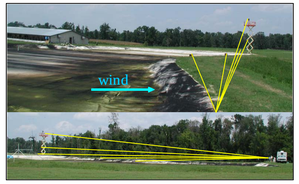
### Area Source Measurement Method

An optical remote sensing technique called Vertical Radial Plume Mapping (VRPM) was developed to quantify fugitive emissions from area sources. The method employs Open-Path Fourier Transform InfraRed (OP-FTIR) and Tunable Diode Laser Spectroscopy (OP-TDLAS) to obtain path-integrated pollutant concentration information along multiple plane-configured optical paths. The multi-path pollutant concentration data along with wind speed and direction information are processed with a computational algorithm to yield a mass emission flux for the source. The technique was verified and applied to characterize $NH_3$ emissions form AFO sources.




The VRPM technique for mass-emission flux measurements has been standardized and automated enabling efficient deployment and use.






### Lagoon Cover Evaluation:

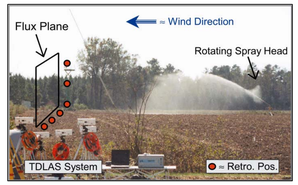
VRPM and OP-FTIR was used to evaluate $NH_3$ lagoon emission with and without cover in 2001 and 2002.

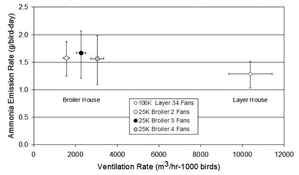
| Test Date (condition) | Emission Flux (g/sec) | Wind Speed (m/sec) | Wind Direction (deg.) |
|---|---|---|---|
| 7/11/2000 (uncovered) | 0.50 | 2.6 | 19.0 |
| 8/16/2000 (covered) | 0.13 | 3.4 | 21.0 |
| 8/16/2001 (covered) | 0.03 | 1.3 | 7.0 |

### Spray Field Evaluation:

VRPM and OP-TDLAS was used to assess $NH_3$ emissions from a hog waste lagoon spraying operation in Nov. 2003.

| Time Period | Emission Flux (g/sec) | Wind Speed (m/sec) | Wind Direction (deg.) |
|---|---|---|---|
| Average (Periods 1-4) | 1.08 | 4.4 | 43.7 |
| Standard Deviation (Periods 1-4) | 0.23 | 0.6 | 13.9 |



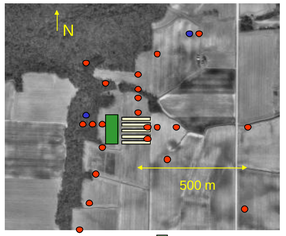




### Poultry House Evaluations:

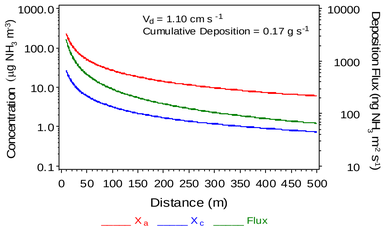
Using a spin-off open-path technique, OP-TDLAS was used to evaluate $NH_3$ emissions from mechanically ventilated layer and broiler poultry houses in 2003 and 2004. A new OP-TDLAS technique to measure $NH_3$ emissions from naturally ventilated animal houses is under development.

### Ammonia Deposition Monitoring

$NH_3$ concentrations are monitored at multiple locations within 500 km of the AFO source complex using passive sampling technology. $NH_3$ concentrations are combined with meteorological data, soil chemistry and plant chemistry to estimate dry deposition using a single-layer resistance model.




Depending on the ambient $NH_3$ concentration ($X_a$) and the concentration of $H^+$ and $NH_4^+$ in leaf apoplast and soil solution, the soil/vegetation surrounding the AFO may be either a sink or additional source of $NH_3$. The deposition model takes into account this "canopy-compensation point ($X_c$)". Using this combined measurement/modeling approach, cumulative dry deposition from the source complex out to a horizontal distance of 500 m can be estimated on a weekly time scale.




## Results/Conclusions

**Area Source Method Developed:**
VRPM technology standardized, verified and in use by several groups.

**AFO $NH_3$ Emissions Measured:**
Swine lagoons tested over seasonal and multi-year campaigns. Naturally ventilated swine and poultry barn emissions measured. Mechanically ventilated barns characterized.

**Ammonia Fate Determined:**
Long-term $NH_3$ deposition measurements conducted at a swine production AFO. Data shows that local $NH_3$ deposition is an important component of the farm-scale nitrogen budget.

Source and fate data combined to quantify the net emission of $NH_3$ from AFO sources.

## Future Directions

**Expand Use of VRPM Method**
Continue development of the VRPM technology for multi-pollutant fugitive area emission assessment for sources including: AFOs, landfills, brownfields, biosolids, industrial facilities and homeland security applications.

**Lower Cost Method Development**
Partner with industry under a CRADA for automated reduced cost TDLAS/VRPM System. Partner with academia and state governments on new passive technology for routine monitoring.

## Impact and Outcomes

**Delivered AFO Emission Factors:**
Teamed with universities and industry to collect AFO $NH_3$ emission data, published in literature, and incorporated into EPA emission inventories.

**VRPM Technique Adopted for Use in EPA Air Compliance Agreement:**
Developed measurement method to be used in the National Air Emissions Monitoring Study Protocol for the EPA-AFO Consent Agreement.

**VRPM Protocol Under Review by EPA:**
Possible assignment as agency standard method for area source emission assessment.

**Developed Measurement Method for $NH_3$ Dry Deposition in the Vicinity of Area Sources:**
Characterized passive sampling technology for monitoring of atmospheric $NH_3$. Used to measure $NH_3$ dry deposition from swine facility.

**Dataset Produced for Modeling:**
Fate data to improve regional atmospheric models for prediction of $NH_3$ emitted from AFOs leading to inorganic $PM_{2.5}$ formation.

Air Quality